Economic Effects on Construction of Uncertainty in Test Methods

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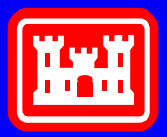

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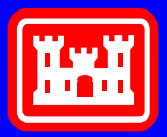
Selected Examples

- CRD-C 114 - F/T dur of aggregates
- ASTM C 78 – flex beam
- ASR testing
- Curing compound testing
- Heat of hydration testing



Test Method Uncertainty

- Within-laboratory variation
  - Operator
  - Equipment
- Between-laboratory variation
- Simple bias
- Material-dependent bias

ASTM

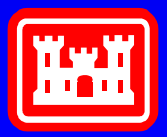
- Requires precision and bias statement
  - Within laboratory - repeatability
  - Between laboratory – reproducibility
- d2s – based on std dev
- d2s% - based on CV

d2s

- Maximum difference among a set of determinations in 95% of cases
- For duplicate determinations,
  - d2s = 2.8*s, or 2.8*CV
- For triplicate determinations,
  - d2s = 3.3*s, or 3.3*CV
- Multipliers for larger sets in ASTM C 670

Example – ASTM C 138 Density of Concrete

- Within-lab std dev = 0.65 lb/ft^3
  - d2s (n=2) = 1.85 lb/ft^3
  - d2s (n=3) = 2.15 lb/ft^3
- Between-lab std dev = 0.82 lb/ft^3
  - d2s (n=2) = 2.31 lb/ft^3



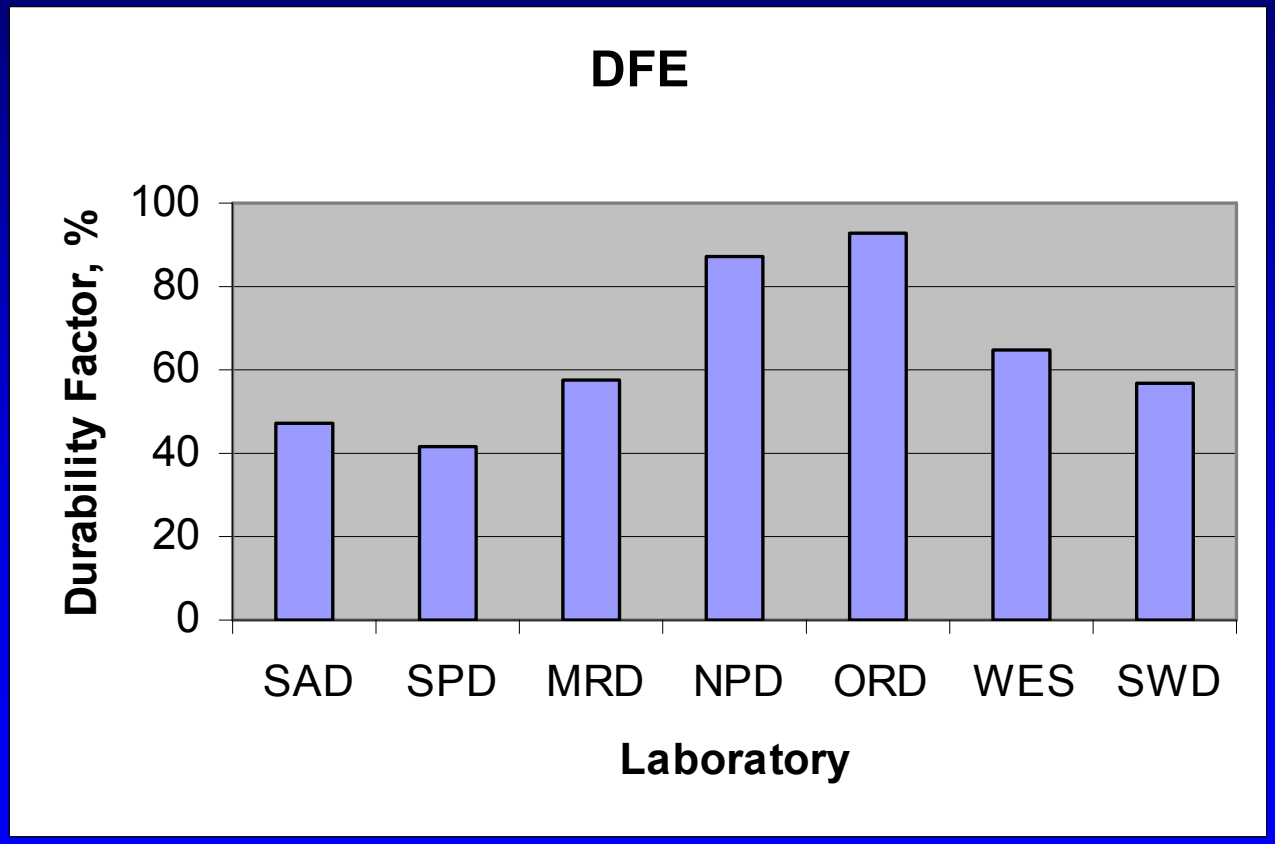
CRD-C 114
Durability of Aggregates to Cycles of Freezing and Thawing

- Acceptance testing of concrete aggregate
- Based on ASTM C 666
  - Air-entrained concrete
  - Results reported as a Durability Factor 0 – 100%
  - 100% Specifications typically 50 – 75%
- No reported precision estimate

CRD-C 114
Durability of Aggregates to Cycles of Freezing and Thawing

- Significant between-laboratory disagreements
- Changes in use of durability factor specifications

Mather 1954

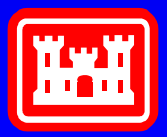

DFE
Durability Factor, %
100
80
60
40
20
0
SAD
SPD
MRD
NPD
ORD
WES
SWD
Laboratory

Precision CRD-C 114

- Standard deviation among labs
  - 19.3%
- d2s among labs
  - 54%

Economic Consequences of Rejection

- Hauling distance to secondary source
- 10 mi of 4 lane highway
  - 120,000 yd^3 of concrete at $0.15/ton/mi
  - 25 mi haul = $450,000
  - 50 mi haul = $900,000

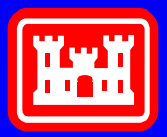


ASTM C 78
Flexural Strength

- Basis for acceptance of mix design
- CV = 7% between laboratory
- At 650 psi
  - d2s ~ 125 psi

Economic Consequences

- Delays over mixture acceptance
- Add extra 100 lb/yd^3 to insure compliance
- 10 mi of 4 Lane
- ~$1,000,000 in cement cost



AAR

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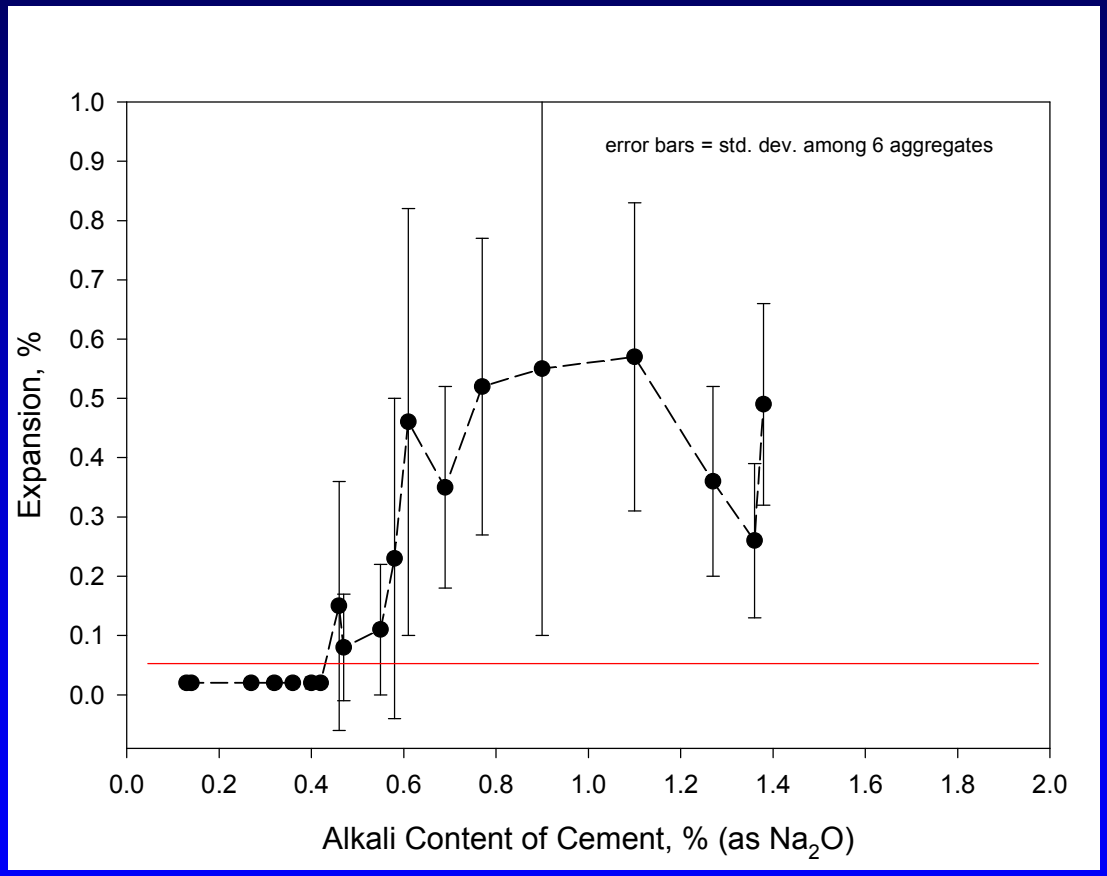
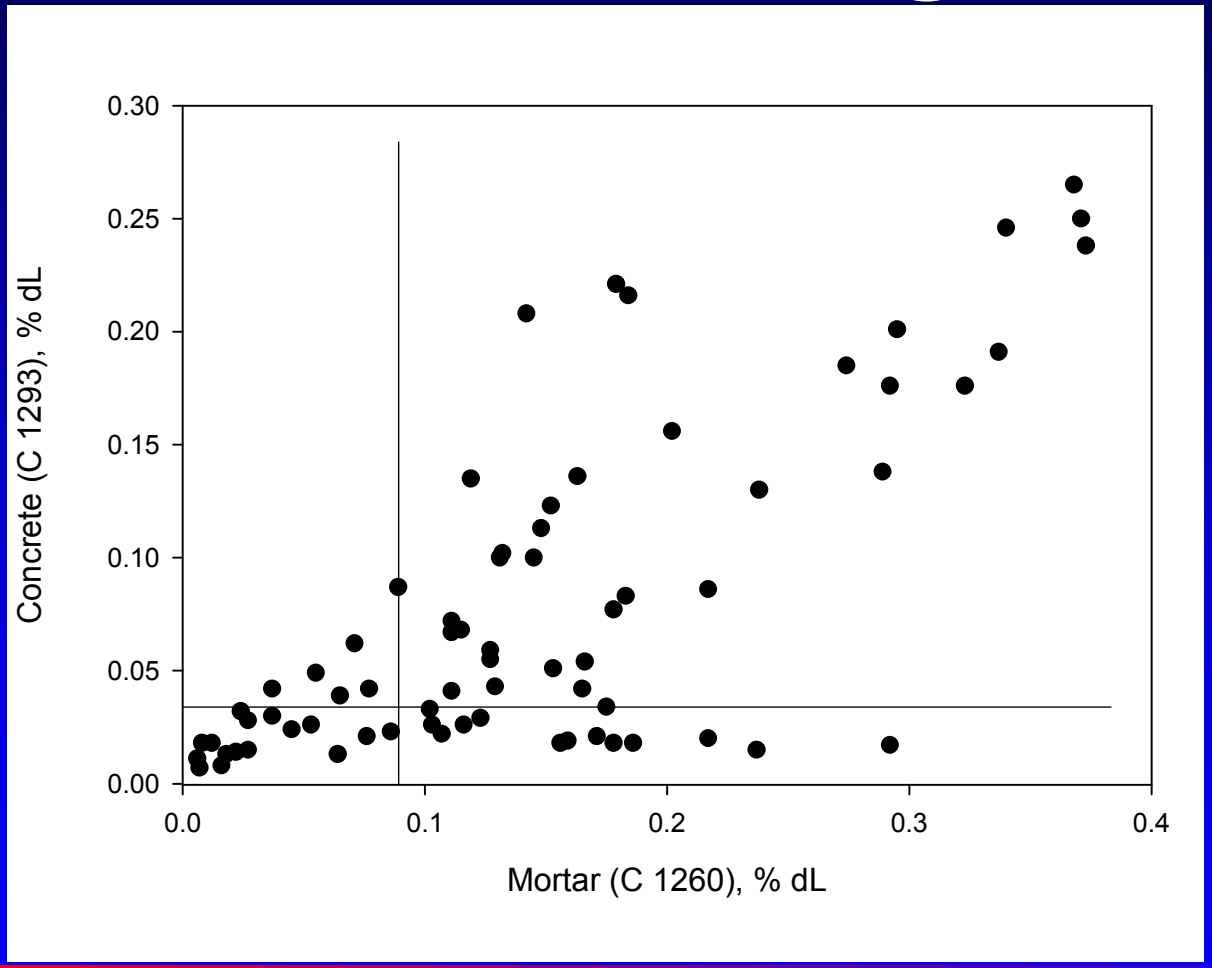
ASTM C 150 – Low Alkali



ASR Testing



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AAR Cost Factors

- Rejection of acceptable aggregate
  - Short term $$
- Acceptance of inadequate aggregate
  - Long term $$

ASTM C 156 – TM for Curing Compounds

ASTM C 156

- Typical limit: 0.55 kg/m^2
- Typical production: 0.45 - 50 kg/m^2
- Between Lab Std dev = 0.07 kg/m^2
- Between Lab d2s = 0.20 kg/m^2

Error > Safety Margin!!

C 156 Cost Factors

- User – producer disputes
- Over conservative specification
  - High solids materials
  - Difficult to apply
- May not perform
- Little testing by Federal Gov't

ASTM C 186
Heat of Hydration of Hydraulic Cement

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ASTM C 186
Heat of Hydration of Hydraulic Cement

- Between Lab std dev = 4 cal/g
- d2s = 11 cal/g
- Represents ~1,000 psi strength difference
- Target strength = 1500 psi, 3 days
- Specification limit = 1000 psi, 3 days

Cost Issues

- Uniformity in Strength Gain
  - Weekly variation ~1,000 psi
- Uncertainty in Form Removal